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ABSTRACT

The Computer-Assisted Instruction (CAI) Laboratory at the University of Texas (UT) has two functions: doing research on improving CAI and also developing and implementing CAI at a university. The Lab uses an IBM 1500 instructional system. This system is flexible enough to be useful in research, but it is too small to support an extensive curriculum effort. Several factors have limited the growth of CAI at UT. Cost of producing and using CAI programs is too high. It cost $13,000 to develop an Arabic course, not counting the cost of evaluation. Also, the cost of terminal hardware and limited number of available terminals drives student-terminal-time costs to $5 an hour. Using CAI for undergraduate lower division courses would cut costs per student, but also would deprive graduate student teachers of income. As a result, the CAI Lab plans to work with MITRE Corporation to demonstrate cost-effective CAI at a junior college, which is thought to be a more fertile ground for CAI. The proposed system, TICCIT, is described here. (JK)

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COMPUTER-ASSISTED INSTRUCTIONAL SYSTEMS FOR HIGHER EDUCATION: PROBLEMS AND PROSPECTS

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Computer-Assisted Instructional Systems for Higher Education: Problems and Prospects

University of Texas CAI Laboratory and 1500 System

The UT CAI Laboratory is envisioned as functioning in two complementary roles: 1) research directed at improving computer-assisted instruction, and 2) the development and implementation of CAI in the university setting. To carry out these functions, the Laboratory maintains an IBM 1500 instructional system. The characteristics of this system relevant to this discussion are that it has a capacity for five disk packs and controls ten instructional terminals. Two of these terminals are not currently available to students but are used by proctors and programmers. Of the remaining eight, two have 1518 typewriters while the other six use the 1510 CRT and keyboard configuration. All eight have image projectors and light pens, and six are supplemented by 1506 fast-access audio units.

During the current semester, terminals are available for student use twelve hours per day, from 8 a.m. until 10 in the evening. The noon and supper hours are used for system utility as is the period from 10 p.m. until midnight. Saturdays are devoted to special projects such as experiments and, currently, an informal course in APL for high school students.

Student scheduling is on an *ad lib* basis in terms of one-hour blocks. That is, students can call in and make appointments to use a particular course during any of the regular hours. Since a major course may require up to four disk packs and since students tend to spread themselves out through a course, the factor which usually limits the number of students who can be on the system at one time is the number of disk packs

rather than the number of terminals. If we required all students working on a particular course to schedule during restricted hours, the limiting factor would be the number of terminals, but thus far such a restriction has not been deemed necessary.

This semester, the system is supporting two major programs which are being used in University classes--a laboratory for a statistics course and a survey of handicapping conditions (developed by the Penn State CAI Laboratory) which is being used in an introductory course in special education. The first requires an average of 15 hours of computer time; the second, 25 hours. In addition, a number of students make use of a pre-calculus math course for a variety of purposes and a small group of Latin American students are taking a course in English punctuation. During the first three weeks of the semester, the system was also used to present the Arabic program as a component of a University Arabic course. While system use was heavier when Arabic was being run and will be heavier again at the end of the semester, terminal utilization is only about 35% at this time.

The 1500 system was designed for research purposes. As was mentioned, this is one of the Laboratory's activities and for these purposes the system is fairly satisfactory. The flexibility provided by the sophistication of the terminal devices is quite advantageous. System response time is slower than might be desired for some purposes. Data retrieval often appears to be unnecessarily cumbersome, but, in general, the system provides a powerful and convenient research tool. Use of the 1500 in a production mode is less satisfactory. The system as it is configured at the University of Texas is much too small to support an extensive curriculum effort.

There are a number of factors, however, which have interacted to limit the extent to which we have been able to establish CAI as an accepted part of the University of Texas curriculum. The costs of developing and using CAI programs are too high. For example, the Arabic course provides about seven hours of interactive student instruction. It cost about $3,600 in personnel time to produce the course and an additional $1,200 to debug it. The program was produced as part of the author's dissertation, and her time is not included in these figures. But since it entailed full-time work for several months, the value of her effort was estimated at about $6,000. Finally, $2,100 worth of computer time was required for the course's production. Thus, the total cost of producing the program was $13,000 including the author's time. But this still doesn't include evaluation.

There are two reasons for these high costs. The first is our insistence on a detailed instructional design approach to the production of the materials. Second, and more important, is the time and expense required for coding and debugging. We recently have attempted to reduce these costs by the development of preprocessor and macro expander programs designed to facilitate the translation of author's draft materials into error-free computer code. The preprocessor was used during the summer for several minor coding projects and thus far appears to be quite satisfactory. It will receive a more thorough evaluation this fall in the production of a full-semester computer-managed instruction course.

Because of the system's relatively expensive terminal hardware and the limited number of terminals available at our facility, student-terminal-time costs are quite high--about $5.00 per hour. There are a number of different ways such costs can be computed and we have had some

debate among ourselves as to what the exact value should be, but it does appear that the appropriate figure is in the neighborhood of $4.00 to $7.00. This value is not currently competitive with the cost of conventional instruction at the University of Texas. The cost could be reduced somewhat by increasing the number of terminals and employing a less flexible scheduling scheme, but we do not feel that the savings from these actions would be that significant. If institutions placed a dollar value on the time students spend preparing for class as well as class time, the comparison would be more favorable to CAI.

For example, evaluation of the Arabic program in comparison to conventional classroom instruction found that four to eight hours of terminal time plus four hours of class time without homework assignments was more effective than 18 hours of regular class with its usual complement of homework.

We have encountered a number of institutional constraints on the further implementation of CAI at the university level. One of the more interesting of these concerns the source of the funds to be used for a CAI program. Since cost per student hour can be reduced if development expenses are distributed over a large population of students, lower division undergraduate courses would appear to be the most promising market for CAI in a university. These courses, however, are usually taught by graduate students. If a department spends funds allocated for these courses on a CAI program, it has lost one means of supporting its graduate students. Given the relative importance attached to the quality of graduate as opposed to undergraduate training, very few departments are willing to divert funds to CAI.

In view of these several considerations, the Laboratory has changed the focus of its major development efforts. During the next few years we will be working with MITRE Corporation in attempting to demonstrate cost-effective computer-assisted instruction in a junior college setting. We think that there are a number of reasons why junior colleges will provide more fertile ground for the growth of CAI than have universities. The most interesting aspect of this project, however, involves the development of a CAI system designed to be cost-effective.

Description of the TICCIT System

The system we are concerned with is called TICCIT (Time-shared Interactive Computer-Controlled Information Television). The system hardware and software are being developed by MITRE Corporation, while the University of Texas and Brigham Young University are developing five courses in mathematics, English, and computer science. MITRE's philosophy in developing TICCIT has been to maximize the use of existing, off-the-shelf hardware while also attempting to capitalize on advances in relevant technology. TICCIT has been designed as a small, relatively inexpensive system which an individual school could afford to buy or lease. MITRE's analysis of CAI facilities found that cost per terminal hour increased rapidly as the number of terminals dropped below 100 but remained relatively stable above 100. The basic TICCIT system was, therefore, designed to support 128 on-line terminals.

The computer subsystem is based on two minicomputers. The first, a Data General SUPERNOVA with 32K of memory, serves as the main processor. The second, a 12K Data General NOVA 800, serves as a terminal processor, handling the fast-reaction, stereotyped interactions with the student terminals. The main processor is supported by slow, low cost peripherals--card reader, line printer, and one magnetic tape unit--and by two large moving-head disk drives to contain the data base and two fixed-head disks to serve as virtual memory.

The smaller, terminal processor receives and processes keyboard entries from the terminals and generates new displays to be sent back to the terminal. It is supported by two fixed-head disks which are used to

store previous frames for updating and retransmission--for example, echoing characters to the student's terminal as they are typed. The terminal processor controls three peripherals, a keyboard signal processor, an audio message generator, and a television character and vector generator. This last device converts character codes and line drawing commands into composite TV pictures, outputting new pictures at a rate of up to 60 per second. Since the device has a large programable character definition memory, the terminal processor can change character fonts to suit different subjects and instructional styles.

TICCIT utilizes a wide-band coaxial cable (as is used for CATV) to distribute signals to the terminals and carry student responses back to the computer. In some installations, TICCIT might have a dedicated cable system but in other situations it could utilize a single channel on an existing CATV system. When the terminal processor assembles a frame for a particular terminal, it adds the number of the terminal to the frame. The number is coded as 16 black and white dashes immediately before the vertical retrace. The frame is then injected into the cable system as a regular TV field, the total signal duration being a 60th of a second. Thus, 60 individual displays can be transferred to the terminals per second.

Each terminal contains a decoder which examines all of the frames on the cable. If a frame's address matches the decoder's address, the decoder "grabs" that frame and records it on a video tape recorder at the terminal. The video tape recorder then serves as a refresh memory for the terminal's television set. Keyboard signals resulting from the student's responses are time-division multiplexed by the terminal electronics

onto the same cable that carried the video signal to the terminal. Thus, TICCIT requires a cable system with two-way signal flow capability. The newer CATV systems now being designed and built have this two-way capability.

A major economic factor in the design of a CAI system is terminal cost since this cost must be replicated n times for each of the n terminals. In its current configuration, the TICCIT terminal consists of a standard television receiver, a video tape recorder, keyboard, and a minimal amount of control electronics. The most expensive component in the terminal is the video tape recorder. Several companies will introduce cassette video tape recorders in the next year, costing in the range of $700 to $800. According to company reports, the price should drop to $400 to $500 in the near future. One of the intriguing aspects of the terminal is the availability of a video cassette recorder for non-CAI use. For example, interactive CAI could be complemented by the use of short, single concept films presented by means of video cassettes.

MITRE has taken an interesting approach to the production of instructional materials for TICCIT. Previous systems, such as the 1500, used special purpose programming languages that attempted to compromise between what an author might find natural and what was easily processed by the computer. While this approach enables naive authors to produce simple instructional programs, the language becomes a liability in any attempt at complex information processing. More recently, the trend seems to have been toward the use of more powerful, general purpose languages, but this approach poses difficulties for most authors. MITRE's intention is to try to provide the author with the best of both worlds by developing

software tools that will allow him essentially to create authoring languages idiosyncratic to the characteristics of the course material and to his particular authoring style. This is being done by the development of a general purpose programming language, the TICCIT language, and the construction of a powerful macro language processor. The author will create his particular stylistic language by defining macros appropriate to his display and response processing needs. It is anticipated that most of the instructional programming will then be done in terms of these macros, with recourse to the TICCIT language when necessary.